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The contribution of granular and fundamental comparative advantage to European Union countries' export specialization*

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Abstract

This paper analyzes the contribution of fundamental comparative advantage (a country-specific component) and granular comparative advantage (a firm-specific component) to European Union countries' export specialization. We find that, on average, granular comparative advantage may explain export specialization in 29% of industries, which account for 47% of total exports. We also show that 60% of the variation in export specialization across countries and industries may be explained by granular comparative advantage. These results highlight that some outstanding firms may play a very important role in explaining European Union countries' export specialization.

JEL: F12, F14

Keywords: exports, fundamental comparative advantage, granular comparative advantage, European Union, export superstars.

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1 Introduction

The question of why countries export some goods and import others is central to positive trade theory (Jones and Neary, 1984). The (neo-) classical models of trade contend that countries export the goods in which they have a comparative advantage and import the goods in which they have a comparative disadvantage. In the Ricardian model comparative advantage emerges from differences in technology and in the Heckscher-Ohlin model from differences in factor endowments. Since these variables are determined at the country level, firms do not play any role in shaping export specialization in the traditional Ricardian and Heckscher-Ohlin trade models.

This contrast with the most recent literature where firms are key to understand aggregate trade outcomes and how countries react to changes in trade costs. This literature stresses that firms are heterogeneous across several dimensions and this heterogeneity explains why some firms become global whereas others remain local.[1] At the beginning, this literature focused on differences across firms within an industry (Melitz, 2003). However, later papers combined firm-heterogeneity with sectoral differences in productivity (Okubo, 2009; Costinot et al., 2012) or factor intensity (Bernard et al., 2007b; Crozet and Trionfetti, 2013) to understand how changes in trade costs led to the reallocation of resources across industries and firms.[2] The empirical literature on firm heterogeneity and trade emphasizes as well that few firms dominate exports (Bernard et al., 2007a, 2012). For example, in a sample of 32 developing countries, Freund and Pierola (2015) conclude that the top firm accounts, on average, for 14% of a country's total (non-oil) exports. This evidence suggests that, sometimes, outstanding firms, rather than country-level variables, may determine a country's export specialization.

This paper analyzes the contribution of fundamental comparative advantage (a country-specific component) and granular comparative advantage (a firm-specific component) to explain European Union (EU) countries' export specialization. Building on Chaney (2008), we develop a methodology which decomposes the observed export specialization into a fundamental comparative advantage component and a granular comparative advantage component. We find that, on average, granular comparative may explain export specialization in 29% of industries, which account for 47% of the bilateral trade among EU countries. We also show that granular comparative advantage may explain 60% of the variation in export specialization across countries and industries, while fundamental comparative advantage may explain the remaining 40% of the variation.

[1] Melitz and Redding (2014) provide a review of the theoretical literature on firm heterogeneity and trade.

[2] Other paper, such as Chor (2010), integrated differences across firms and industries into a single model to quantify the contribution of Ricardian, Heckscher-Ohlin and institutional sources to the differences in trade flows and welfare.

Our paper is related to the literature that analyzes the contribution of granular and fundamental comparative advantage to export specialization. Two methodologies have been proposed to identify these contributions. First, Freund and Pierola (2015) analyze whether countries' revealed comparative advantage would alter if the top exporters disappeared. In this approach, granular comparative advantage dominates if revealed comparative advantage disappears once the top exporters are removed; in contrast, fundamental comparative advantage prevails if revealed comparative advantage remains even when the top firms are removed. The limitation of this methodology is that it demands firm-level export data at the country level. Second, Gaubert and Itskhoki (2018) develop a general equilibrium model with a finite number of firms. They apply a simulated method of moments to calculate the contribution of fundamental and granular comparative advantage to export specialization in France. This methodology, in addition to firm-level export data, demands information on firm-level domestic sales. Since we do not have data to apply these methodologies, we propose an alternative framework to identify the granular and fundamental components of EU countries' export specialization. Building on Chaney (2008), we show that under some conditions, fundamental comparative advantage can be approximated by the number of exporters. Then, as in Gaubert and Itskhoki (2018), we calculate granular comparative advantage as the difference between the actual export specialization and fundamental comparative advantage. By applying our methodology, to the best of our knowledge, we are the first authors to determine the contribution of granular and fundamental comparative advantage to EU countries' export specialization.

The rest of the paper is organized as follows. Section 2 builds upon Chaney's (2008) model to develop a methodology to estimate fundamental and granular comparative advantage. Section 3 applies our methodology to estimate fundamental and granular comparative advantage in EU countries' export specialization. Section 4 concludes.

2 A methodology to estimate the contribution of fundamental and granular comparative advantage to export specialization

Following French (2017), we define export specialization as a bilateral measure, and relative to a reference country and industry

$$XS_{ijk} = \frac{X_{ijk}/X_{ijk'}}{X_{i'jk}/X_{i'jk'}} \tag{1}$$

where XS_{ijk} is the export specialization of country i, in industry k and destination j. k' is the reference industry and i' the reference country.

Following Gaubert and Itskhoki (2018), we define granular comparative advantage (GCA) as the difference between export specialization and fundamental comparative advantage (FCA)

$$GCA_{ijk} = XS_{ijk} - FCA_{ijk} \tag{2}$$

To determine FCA, we follow Chaney (2008). In this model, firms are heterogeneous in productivity. There is an exogenous mass of potential entrants in the market. This mass of entrants is large enough, so firms will occupy all the available productivity levels in the proportion dictated by the productivity distribution. In this environment, firms' particular draws cannot determine export specialization. That is, granularity does not play any role.

Firms produce horizontally-differentiated varieties within an industry with monopolistic competition, labor is the only production factor, and preferences of a representative consumer are given by a constant elasticity of substitution (CES) utility function. To determine export specialization, we begin by decomposing exports into the number of exporters, the extensive margin, and the average exports per firm, the intensive margin:

$$X_{ijk} = N_{ijk}\overline{x}_{ijk} \tag{3}$$

where N_{ijk} is the number of firms located in country i that export industry k varieties to country j, and $\overline{x}_{ijk}$ is the average exports per firm.

As shown in Appendix A, the intensive margin of exports is determined by

$$\overline{x}_{ijk} = \left(\frac{\theta\sigma}{\theta - \sigma + 1}\right)F_{ijk} \tag{4}$$

where σ is the elasticity of substitution and F_{ijk} is the fixed cost of exporting k industry varieties from country i to country j. The shape parameter θ measures the heterogeneity of the productivity distribution, with higher values meaning less heterogeneity. Productivity is Pareto distributed.

As explained in Appendix A, the extensive margin of exports is determined by the following expression

$$N_{ijk} = T_{ik}\underline{z}_{ijk}^{-\theta} \tag{5}$$

where $\underline{z}_{ijk}$ is the threshold productivity that firms in country i should reach in order to obtain profits from exporting k industry varieties to country j; and, T_{ik} is the productivity of country i in industry k. Following Costinot et al. (2012), we denote this last parameter as the fundamental productivity of country i in industry k. According to (5), the number of exporters will be larger the lower the threshold productivity to export, and the larger the fundamental productivity and the heterogeneity of the productivity distribution.

As shown in Appendix A, the export-threshold is determined by the following expression

$$\underline{z}_{ijk} = \left(\frac{F_{ijk}}{\mu\beta_{jk}Y_j}\right)^{(1/\sigma-1)}\left(\frac{w_i\tau_{ijk}}{P_{jk}}\right) \tag{6}$$

where $\mu = (\sigma - 1)^{\sigma-1}\sigma^{-\sigma}$; β_{jk} is the share of income that country j devotes to consuming industry k varieties; Y_j is the income of country j; w_i is the wage in country i; τ_{ijk} is an iceberg-type trade cost, denoting the units of an industry k variety that should be sent from country i to ensure that one unit arrives in country j; finally, P_{jk} is the price index of industry k varieties in country j.

Substituting (4), (5) and (6) in (3) we can express the total value of exports as

$$X_{ijk} = T_{ik}F_{ijk}^{\frac{\sigma-\theta-1}{\sigma-1}}\tau_{ijk}^{-\theta}(\mu\beta_{jk}Y_j)^{\frac{\theta}{\sigma-1}}\left(\frac{w_i}{P_{jk}}\right)^{-\theta} \tag{7}$$

If we substitute (7) in (1), the variables M_i, μ, β_{jk}, Y_j, w_i, and P_{jk} cancel out, leaving the expression

$$XS_{ijk} = \left(\frac{T_{ik}/T_{ik'}}{T_{i'k}/T_{i'k'}}\right)\left(\frac{F_{ijk}/F_{ijk'}}{F_{i'jk}/F_{i'jk'}}\right)^{\frac{\sigma-\theta-1}{\sigma-1}}\left(\frac{\tau_{ijk}/\tau_{ijk'}}{\tau_{i'jk}/\tau_{i'jk'}}\right)^{-\theta} \tag{8}$$

Note that the first ratio of ratios on the right-hand side of (8) is the Ricardian comparative advantage of country i in industry k. We denote the Ricardian comparative advantage as fundamental comparative advantage. According to (8), export specialization is the product of fundamental comparative advantage, the ratio of fixed export costs ratios, and the ratio of variable export costs ratios.

If we substitute (3) and (4) in (1), we can also express export specialization as

$$XS_{ijk} = \left(\frac{N_{ijk}/N_{ijk'}}{N_{i'jk}/N_{i'jk'}}\right)\left(\frac{F_{ijk}/F_{ijk'}}{F_{i'jk}/F_{i'jk'}}\right) \tag{9}$$

Costinot et al. (2012) use (8) to estimate countries' fundamental comparative advantage from actual export specialization. However, if the number of entrants is small, actual export specialization is determined not only by trade costs and fundamental comparative advantage, but also by granular comparative advantage. In this environment, the outstanding productivity draw of a particular firm can determine a country's export specialization (Eaton et al., 2012).

We take two steps to calculate fundamental comparative advantage in an environment characterized by a small number of entrants. First, if $F_{ijk}/F_{ijk'} = F_{i'jk}/F_{i'jk'}$ and

$\tau_{ijk}/\tau_{ijk'} = \tau_{i'jk}/\tau_{i'jk'}$, according to Equation (8), export specialization will be determined by fundamental comparative advantage only and, according to Equation (9), this will be equal to the ratio of exporters ratios:[3]

$$XS_{ijk} = \frac{T_{ik}/T_{ik'}}{T_{i'k}/T_{i'k'}} = \frac{N_{ijk}/N_{ijk'}}{N_{i'jk}/N_{i'jk'}} \tag{10}$$

Second, we argue that the ratio of exporters ratios we observe in reality is a good approximation of the ratio of exporters ratios we would observe if the number of exporters, as in Equation (10), was the outcome of the productivity draws of a large number of entrants. Therefore, based on Equation (10), we could use the ratio of exporters ratios we observe in reality to measure fundamental comparative advantage.

To support our argument, we combine Equations (A12) and (A13) in Appendix A, to identify the variables that determine the number of exporters in an environment where the number of entrants is large:

$$N_{ijk} = M_{ik}\Big(\underline{z}_{ijk}/\varphi_{ik}\Big)^{-\theta} \tag{11}$$

where M_{ik} is the number of entrants to industry k in country i and φ_{ik} is the minimum productivity that firms in country i can get in industry k. Eaton et al. (2012) show that when the number of draws is small, N_{ijk} is the realization of a random variable that follows a Poisson distribution with parameter $\lambda = M_{ik}(\underline{z}_{ijk}/\varphi_{ik})^{-\theta}$. The expected value of a random variable in a Poisson distribution is λ. Therefore, the expected number of exporters in a small number of draws scenario (a granular scenario) is the same as in the large number of draws scenario.

Although the expected number of exporters is the same in both scenarios, the realization might differ from the expectation. If the discrepancy is large, the ratio of exporters ratios will not provide a good approximation to fundamental comparative advantage. We use numerical simulations to calibrate the extent of this discrepancy. We perform the simulation for alternative values of M_{ik}, $\underline{z_{ijk}}/\varphi_{ik}$ and θ. For each set of values, we calculate the λ parameter and draw a random number from the Poisson distribution governed by this parameter. This draw is the realized number of exporters. We take a draw for each N in Equation (10) and calculate the realized ratio of exporters ratios. We repeat this process 100 times. Then, we calculate the coefficient of variation of the realized ratio of exporters ratios relative to the ratio of exporters ratios we would expect if the number of entrants was large.[4]

[3]Note that the same simplification can be achieved if, following French (2017), we divide export costs into an origin-destination specific export cost and an industry-destination specific export cost $F_{ijk} = F_{ij}F_k; \tau_{ijk} = \tau_{ij}\tau_{jk}$

[4]This latter number is obtained after calculating the number of exporters in each category by Equa-

Appendix B presents the results of the numerical simulations. The coefficient of variation is small across a range of alternative parameter values. This result confirms that the ratio of exporters ratios we observe in reality is a good approximation of the ratio of exporters ratios we would observe if the number of entrants was large. Therefore, the observed ratio of exporters ratios is an accurate approximation of fundamental comparative advantage.[5]

3 The estimation of the fundamental and granular components of EU countries' export specialization

We divide this section in four parts. First, we show that the equality in relative export costs is a fair assumption when analyzing EU countries' exports to other EU partners. Second, we provide some summary statistics on the EU countries included in the sample. Third, we estimate the contribution of fundamental and granular comparative advantage to EU countries' export specialization. Finally, we test the robustness of our results.

3.1 Relative export costs in EU countries' trade

To apply our methodology, we need to show that the equality in relative fixed and variable export costs is a fair assumption for EU countries' trade. It is important to stress that this simplification only demands equality in *relative* export costs, and not in *absolute* export costs. For example, if the cost of exporting cars from EU country i to EU country j is three times the cost of exporting motorcycles from EU country i to EU country j, we need to select a reference EU country i' where the cost of exporting cars to EU country j is also three times larger than the cost of exporting motorcycles.

Fixed costs combine the expenses that exporters made in their country (e.g. the costs of drafting a contract for a foreign delegate) and in the destination country (e.g. the legal costs of opening a delegation). There are differences in regulatory and legal costs across EU countries.[6] However, since we measure fixed export costs in an industry relative to a reference industry, these country-level differences cancel out. Furthermore, mutual recognition eliminates the fixed costs of adapting products to meet the technical

tion (11).

[5]This conclusion is in line with Minondo (2017), who compares the share of expert chess players across countries predicted by a model with a continuum of players and a model with a finite number of players. Using a simulated method of moments, he shows that, for moderate levels of expertise, equivalent to a low z_{ijk}/φ_{ik} ratio, the continuum and discrete models predict very similar percentages.

[6]For example, according to the World Bank's Doing Business 2017 report, the ease of doing business in Denmark, the United Kingdom or Sweden was much higher than in Greece or Italy. Available at: http://www.doingbusiness.org/~/media/WBG/DoingBusiness/Documents/Annual-Reports/English/DB17-Report.pdf

and safety standards of other EU countries.

Variable export costs combine transport and other trade barriers, such as communication costs and tariffs. Transport costs depend on itinerary, transport mode and commodity (Combes and Lafourcade, 2005). Most trade among EU countries uses roads as the mode of transport, so it is reasonable to assume that all commodities will follow the same itinerary from EU country of origin A to the EU country of destination B. Differences across countries in communication costs are canceled given that we measure trade costs in an industry relative to a reference industry. Finally, the absence of tariffs and quotas in intra-EU trade removes a source of variation in relative export costs.

To ensure that our samples only includes EU countries that have similar relative variable export costs, we draw data on the value and quantity of exports and imports for all EU countries' bilateral flows, for the 96 industries included in the Harmonized System 2-digit classification.[7] For each bilateral flow, we compare the value and quantity of exports reported by the EU country of origin[8], measured FOB, with the mirror value and quantity of imports reported by the EU country of destination, measured CIF. If all statistical agencies followed the same registration methods, and there were no errors recording trade flows, the quantity reported by the exporter should equal the mirror quantity reported by the importer; and the export value ought to be smaller than the mirror import value. If these conditions were met, the CIF/FOB ratio would be a good proxy for export costs. However, for many flows these conditions are not met.[9]

To calculate consistent CIF/FOB ratios, we follow the methodology proposed by Guillaume et al. (2008). First, we select the flows where the exported quantity/imported quantity ratio is in the [0.9-1.1] range. Only 15% of the flows in our dataset fall in that range. Second, we calculate a unit value-based CIF/FOB ratio

$$CIF_u/FOB_u = \frac{p_{ij}^M q_{ij}^M / q_{ij}^M}{p_{ij}^X q_{ij}^X / q_{ij}^X} \tag{12}$$

where q_{ij}^M is the quantity that country j imports from country i, and q_{ij}^X is the quantity that country i exports to country j; p_{ij}^M and p_{ij}^X are the price of imports and exports, respectively. The numerator provides the unit value of imports, measured CIF, and the denominator measures the unit value of exports, measured FOB. We only select trade flows whose CIF_u/FOB_u ratio is in the [1-2] range. This additional condition reduces the sample to 8% of the original observations.

We calculate the ratio of trade cost ratios for all origin, destination and industry

[7]Data are available at http://ec.europa.eu/eurostat. We use data for 2008.

[8]Due to their very small size, we exclude Cyprus, Luxembourg and Malta from the sample.

[9]In some transactions the FOB value is larger than the mirror CIF value; in others, there are substantial discrepancies between the export quantity and the mirror import quantity.

combinations. The median ratio of ratios is 0.992 and the mean is 1.011. These figures indicate than, on average, there is equality in relative export costs in EU countries' trade flows. To abide stringently with the equality in relative export cost assumption, we analyze whether some EU countries have a large number of ratio of trade cost ratios that significantly differ from the median value. In particular, for each EU country, we identify the ratios that are below 0.9 or above 1.1. For each country, we calculate the trade value captured in those outlier ratios as a share of the total trade. We find that there are 10 countries whose trade in outlier ratios represents more than 50% of their trade. We decide to remove those countries from the sample.[10] Our final sample is composed by 14 EU countries: Austria, Belgium, France, Germany, Hungary, Italy, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia and Spain. In the last subsection we test whether our results are robust to using the whole EU countries' sample. We show that there are not qualitative changes to our results.

3.2 Data

Data on the number of exporters and value of exports per industry are obtained from the OECD-Eurostat Trade by Enterprise Characteristics Database (Araújo and Gonnard, 2011; Eurostat, 2016).[11] For each EU country× manufacturing industry combination, the database provides the number of exporters and the value of exports to EU countries as a whole over the 2008-2013 period.[12]

Our export data is measured in gross value and, hence, it incorporates the value of the imported inputs that are used in exports. The use of intermediate inputs is expected to be especially intense for superstar exporters, since there is a large correlation between firms' export and import activities (Bernard et al., 2018). Koopman et al. (2014) show that if value-added based trade data is used, instead of gross trade data, there may be changes in countries' revealed comparative advantage measures. Since we do not have access to value-added based bilateral export data, we recognize this limitation in our analysis.

Table 1 presents summarized statistics for the 14 EU countries included in the sample. Italy is the country with the highest number of exporters, followed by Germany and Poland. Germany is the largest exporter to other EU countries, followed by Italy, France

[10] The EU countries removed from the sample are Bulgaria, the Czech Republic, Denmark, Estonia, Finland, Greece, Ireland, Latvia, Sweden and the United Kingdom.

[11] This database is available at http://stats.oecd.org

[12] The database includes 21 manufacturing industries. Since data for tobacco and refined petroleum industries are confidential in many countries, we exclude them from the analysis. The industries included in the sample are: food products, beverages, textiles, apparel, leather, wood, paper, printing, chemicals, pharmaceuticals, rubber, other non-metallic mineral products, basic metals, metal products, computers and electronics, electrical equipment, machinery, motor vehicles, other transport equipment, furniture and other manufacturing.

and Belgium. There is a positive correlation between the number of exporters and GDP (0.75). This result is in line with previous studies that have analyzed the relationship between countries' economic size and the number of exporters (Fernandes et al., 2015). We also find a positive correlation between GDP and exports (0.95), a result which is in line with numerous previous studies on the gravity of trade (Head and Mayer, 2014). Since EU countries' exports are concentrated in manufactures, our sample covers the bulk of intra-EU merchandise exports. Furthermore, since the EU is a major destination for EU members' exports, our sample also covers a sizable share of countries' total merchandise exports. Finally, the table shows that most manufacturing exports to other EU countries are transported by road.[13]

To calculate the ratio of exporters ratios, and the ratio of export value ratios, we need a reference country and a reference industry. To maximize observations, we should select as a reference the country that exports in most industries, and the industry with the highest number of exporting countries. However, there are several countries and industries that meet these criteria. Since some empirical calculations might be sensitive to selecting a specific reference country and industry, we calculate the ratio of exporters ratios and the ratio of export value ratios for all possible reference country+industry combinations. Then, we calculate the average of each ratio for each country and industry. Hence, we measure EU countries' export specialization relative to an average EU country and industry.[14]

Since the ratio of export value ratios and the ratio of exporters ratios are not bounded from above, they might take outlier values. To attenuate the effect of outliers, we transform export specialization and the ratio of exporters ratios into log values. We calculate granular comparative advantage as the difference between the log of actual export specialization and the log of the ratio of exporters ratios. It is important to point out that, empirically, we calculate granular comparative as a residual. Hence, it may capture the effects of variables that are not purely granular and other non-Ricardian fundamental sources. Therefore, our methodology provides rough estimates on the relative contributions of fundamental and granular comparative advantages to export specialization.

Figure 1 presents a scatter diagram of (log) export specialization and (log) fundamental comparative advantage. There is a positive correlation between both variables: the larger the fundamental comparative advantage, the larger the export specialization. If export specialization was explained by the fundamental comparative advantage only, all dots would lie on the 45° line. However, we observe that dots scatter around the 45° line. The dots above the 45° line are country+industry combinations where granular comparative advantage is positive, whereas the dots below the 45° line are country+industry

[13]We get these data from Eurostat's international trade database. Data correspond to 2013.

[14]This methodology also strengthens the assumption of equal relative export costs, since the median ratio of trade cost ratios is 1.

combinations where granular comparative advantage is negative. A positive granular comparative advantage arises when a firm draws an outstanding productivity, driving the industry's intensive margin above the average. A negative granular comparative advantage captures situations where the productivity drawn by firms is lower than expected, driving the intensive margin below the average.

3.3 The contribution of fundamental and granular comparative advantage to export specialization

We identify, first, the industries in which EU countries reveal a comparative advantage (export specialization larger than one). We say an industry is granular if granular comparative advantage is larger than fundamental comparative advantage. For each country, we calculate the percentage of granular industries over (i) all industries, (ii) industries with a revealed comparative advantage, and (iii) total exports. Table 2 presents these calculations for the 14 EU countries included in our sample. On average, 29% of industries are granular, they represent 56% of industries with a revealed comparative advantage and account for 47% of exports.

The highest percentage of granular industries, 43%, is found in Slovakia, and the lowest percentage, 14%, in France and Germany. In Hungary, granular industries represent 80% of the industries in which this country has a revealed comparative advantage. The percentage drops to 30% in France and Germany. Exports generated in granular industries represent 71% of Hungarian exports, but only 27% of Slovenian exports. In Hungary, the weight of granular exports is explained by the motor vehicles and computers and electronics; in the Netherlands, the second country with the highest percentage of granular exports, food products and chemicals are the most important granular industries; in Slovakia, motor vehicles explain the weight of granular exports.

There is a negative correlation between GDP and the percentage of exports in granular industries (-0.43). However, there are countries, such as Slovenia or Portugal, where the share of granular industries in total exports is lower than in larger countries, such as Germany or Spain. This suggests that, along with country size, what industries are granular also determines the weight of granular industries in total exports.

To test the validity of our methodology, we compare the industries identified as granular and non-granular with our methodology in Spain, with the industries that de Lucio et al. (2017) identify as granular and non-granular using Freund and Pierola's (2015) methodology. Despite the differences in samples and industry classifications, we find coincidences for many industries.[15] Moreover, the percentage of Spanish exports explained

[15] In particular, for industries that have a revealed comparative advantage in both samples, both studies coincide to identify as granular basic metals, motor vehicles and transport equipment; and as

by granular industries in de Lucio et al. (2017), 45%, is almost the same as the one calculated with our methodology, 47%.

Next we analyze the contribution of fundamental comparative advantage and granular comparative advantage to explain the differences in export specialization across countries. To perform this analysis, we use a regression-based decomposition. We regress each comparative advantage component on export specialization, exporter fixed effects (γ_i), and industry fixed effects (γ_k). Specifically,

$$\begin{aligned} \ln FCA_{ik} &= \beta_1 \ln XS_{ik} + \gamma_i + \gamma_k \\ \ln GCA_{ik} &= \beta_2 \ln XS_{ik} + \gamma_i + \gamma_k \end{aligned} \tag{13}$$

Figure 2 presents the results of the regression-based decomposition for *granular* comparative advantage. First, we perform the decomposition by pooling all observations; next we carry out country-specific decompositions. When we pool all observations, 60% of the variation in export specialization across countries, and across industries within a country, are explained by granular comparative advantage, and 40% by fundamental comparative advantage. These results show that, on average, granular comparative advantage may play a larger role than fundamental comparative advantage in explaining the differences in export specialization across EU countries, and across industries within a EU country.

Next we estimate the contribution of fundamental and granular comparative advantage to the variation in export specialization within each country. We run a separate regression for each country included in the sample.[16] In 9 out of the 14 countries, the contribution of granular comparative advantage is larger than the contribution of fundamental comparative advantage. The highest contribution of granular comparative advantage is in Slovenia (91%), followed by Hungary (88%) and Austria (78%). The countries with the highest contribution of fundamental comparative advantage are Spain (64%), Portugal (59%) and Germany (55%). We find a positive correlation between GDP and the contribution of fundamental comparative advantage (0.58), which might be explained by the relative lower influence of large exporters in high GDP countries.

Gaubert and Itskhoki (2018) estimate the contribution of granular and fundamental comparative advantage to differences in export specialization across French industries.

non-granular food products and beverages. They do not coincide in chemicals, which is identified as granular in de Lucio et al. (2017) and non-granular in our sample; and in non-metallic minerals, which is identified as granular in our sample and as non-granular in de Lucio et al. (2017). This latter paper calculates revealed comparative advantage relative to the world, whereas in this paper we measure it relative to a sample of EU countries.

[16]This specification does not include neither exporter fixed effects(γ_i), since there is no variation across exporters, nor industry fixed effects (γ_k), since they would be collinear with the rest of variables.

They find that 70% of the variation in export specialization is due to fundamental comparative advantage. This figure is larger than our estimate: 52%. Gaubert and Itskhoki (2018) analyze France's export specialization vis a vis the rest of the world, while we analyze it vis a vis an average EU country. Since differences in the sources of fundamental comparative advantage are larger across countries in the world than across EU countries, it is reasonable to expect a higher contribution for fundamental comparative advantage when export specialization is measured relative to the former than to the latter.

To sum up, our analyses show that granular comparative advantage may play an important role in shaping a EU country's export specialization relative to an average EU country. On average, granularity may define export specialization in 29% of industries and granular industries may account for 47% of total manufacturing exports. Moreover, granular comparative advantage may explain 60% of the differences in export specialization across EU countries, and across industries within a EU country.

3.4 Sensitivity analyses

We perform some sensitivity analyses to test the robustness of our results. First, the empirical literature shows that many firms export one year and cease to export the following year. These intermittent exporters may introduce noise in our fundamental comparative advantage estimates.[17] The literature also suggests that firms with more employees are more likely to be regular exporters. We test whether our main results are altered if we select exporters with 10 or more employees only. Due to the absence of data, the sample is reduced to 9 countries. Table 3 presents information on granular industries. The percentage of granular industries, their share in industries where export specialization>1, and their share in total exports are very similar to those found in the baseline analysis. Country-level results are also very similar. Figure 3 presents the regression decomposition results. When all countries and industries are pooled, the contribution of fundamental comparative advantage rises to 43%, and the contribution of granular comparative advantage declines to 57%. In any case, these percentages are similar to those obtained in the baseline analysis.

Second, we use less stringent thresholds to determine the EU countries included in the sample. For this sensitivity analysis, we use data for the period 2008-2013 to calculate the unitary CIF and FOB ratios. We widen the exported quantity/imported quantity ratio from the [0.9, 1.1] range to the [0.75,1.25] range. Then we extend the unit value CIF/unit value FOB from the [1,2] range to the [1,3] range. These changes raise the flows included in the sample from 8% to 15%. Next, for each EU country, we identify the

[17]See, among others, Görg et al. (2012), Cadot et al. (2013), Esteve-Pérez et al. (2013), and Albornoz et al. (2016).

relative cost ratios that are below 0.75 and above 1.25, instead of the 0.9-1.1 range used in our baseline analysis. With these less stringent threshold conditions there is no EU country that has more than 50% of its trade value outside the 0.75-1.25 trade cost ratio range. Hence, for this sensitivity analysis, the sample of countries enlarges from 14 to 24. The new countries included in the sample are Bulgaria, the Czech Republic, Denmark, Estonia, Finland, Greece, Ireland, Latvia, Sweden and the United Kingdom.

Table 4 presents information on granular industries for the extended sample. On average, 28% of industries are granular, they represent 58% of industries with a revealed comparative advantage, and account for 49% of exports. These percentages are very similar to those calculated with the baseline sample of EU countries (Table 2). There are some changes in the percentages among the countries that were included in the baseline sample. This is because the addition of new countries alters the average ratio of exporters ratios and the ratio of export value ratios for each country and industry. In any case, these changes are not qualitatively significant. Among the new countries, we should highlight the large share of granular industries in Ireland exports and the low share of granular industries in UK exports. Granular industries also account for a large share of exports in Czech Republic, Estonia and Finland.

Figure 4 presents the regression decomposition results. When all countries and industries are pooled, the contribution of fundamental comparative advantage drops to 33%, and the contribution of granular comparative advantage rises to 67%. In any case, these percentages do not differ significantly from those obtained in the baseline analysis (40% vs 60%). In all the new countries granular comparative advantage plays a larger role than fundamental comparative advantage to explain the differences in specialization across industries. The contribution of granularity is specially remarkable in Ireland, Czech Republic and Finland.

Third, we analyze whether our results are robust over time. To do so, we examine whether the contribution of granular comparative advantage changes from 2008 to 2013. To perform this analysis, we only include in the sample the countries that provide data for both 2008 and 2013. The share of granular industries in all industries, revealed comparative industries and total exports is similar in 2008 and 2013 (Table 5). The percentages are also similar to those reported in the baseline analysis, based on 2008-2013 averages (Table 2). At the country level, we observe non-negligible drops in the share of granular industries between 2008 and 2013 in Germany, Hungary and Italy, and significant increases in Spain and Poland. In any case, we should take these results with caution since one-year data are more likely to be influenced by outlier observations. The contribution of granular comparative advantage to the variation in export specialization within each country is similar in 2008 and 2013 (Figure 5). At the country, level the only significant change happens in Germany, where the share of granular comparative advantage drops from 47% in 2008 to 29% in 2013.

4 Conclusion

In this paper we assess the contribution of Ricardian sectoral productivity differences (fundamental comparative advantage) and firm idiosyncrasies (granular comparative advantage) to the definition of export specialization across and within EU countries. To do so, we develop a methodology that takes advantage of the similarity in relative export costs in EU countries' trade. We show that, on average, granular comparative advantage may define export specialization in 29% of industries and may account for 47% of a EU country's exports. We also show that 60% of the differences in export specialization across EU countries may be explained by granular comparative advantage.

Our results highlight that EU countries' export specialization is not determined solely by country-level variables, such as average productivity or endowments, that may change slowly over time, but also by outstanding firms. EU countries seeking to alter their export specialization should create an environment for new outstanding firms to emerge, or attract outstanding firms from other countries.

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Table 1: OECD-Eurostat Database: Summary statistics for the EU countries in the sample

Country	Period	Number of manufacturing exporters to the EU	Intra-EU manufacturing exports (million USD)	Sample's coverage of merchandise intra-EU exports(%)	Sample's coverage of total merchandise exports(%)	Share of export value to the EU by road
Austria	2008-2013	8211	75367	95	66	n.a.
Belgium	2011-2013	11719	123111	93	70	81
France	2008-2013	17248	207773	94	59	n.a.
Germany	2008-2013	51924	427052	96	53	85
Hungary	2008-2013	8900	53672	98	78	93
Italy	2008-2013	72012	213979	99	57	88
Lithuania	2008-2013	2521	11426	79	57	65
Netherlands	2009-2013	10741	105570	73	55	n.a.
Poland	2008-2013	22247	93386	94	75	88
Portugal	2008-2013	12534	29498	90	70	78
Romania	2008-2012	7376	27550	95	69	89
Slovakia	2008-2013	3064	31649	92	76	80
Slovenia	2009-2013	n.a.	n.a.	87	65	n.a.
Spain	2008-2013	18459	116616	63	42	76

Source: OECD-Eurostat Trade by Enterprise Characteristics database and Eurostat's Trade database. Note: Number of exporters, intra-EU exports and sample coverages are the average for the period. Share of exports value by road corresponds to 2013. n.a.: Not available. Some countries, due to confidentiality problems in some industries, do not provide aggregate data either.

Table 2: Granular industries by country (Average 2008-2013)

Country	% of granular industries	Share of granular in XS >1 industries	% of granular exports
Average country	29	56	47
Austria	29	60	36
Belgium	24	56	44
France	14	30	30
Germany	14	30	38
Hungary	38	80	71
Italy	29	50	29
Lithuania	33	70	63
Netherlands	38	62	70
Poland	33	70	64
Portugal	19	40	30
Romania	33	70	57
Slovakia	43	69	66
Slovenia	29	46	27
Spain	29	55	47

Source: Authors' calculations using the OECD-Eurostat Trade by Enterprise Characteristics database. Note: XS=Export specialization. Among industries with export specialization >1, granular industries are defined as those where granular comparative advantage is larger than fundamental comparative advantage.

Table 3: Small firms removed. Granular industries by country (Average 2008-2013)

Country	% of granular industries	Share of granular in XS >1 industries	% of granular exports
Average country	31	63	49
Austria	33	78	38
Belgium	29	60	45
France	14	33	22
Germany	29	50	53
Hungary	38	80	71
Italy	33	58	24
Poland	33	70	65
Romania	33	70	57
Spain	33	58	53

Source: Authors' calculations using the OECD-Eurostat Trade by Enterprise Characteristics database. Note: XS=Export specialization. Among industries with export specialization >1, granular industries are defined as those where granular comparative advantage is larger than fundamental comparative advantage.

Table 4: Extended sample. Granular industries by country (Average 2008-2013)

Country	% of granular industries	Share of granular in XS >1 industries	% of granular exports
Average country	28	58	49
Austria	29	60	33
Belgium	29	60	56
Bulgaria	29	75	44
Czech Republic	38	73	69
Denmark	30	60	48
Estonia	38	73	51
Finland	24	45	54
France	10	20	29
Germany	19	44	37
Greece	33	64	48
Hungary	29	86	68
Ireland	32	86	89
Italy	24	56	22
Latvia	29	67	31
Lithuania	33	70	69
Netherlands	38	62	70
Poland	29	55	62
Portugal	24	45	37
Romania	33	70	57
Slovakia	38	67	64
Slovenia	33	54	49
Spain	24	45	44
Sweden	25	45	39
United Kingdom	14	27	18

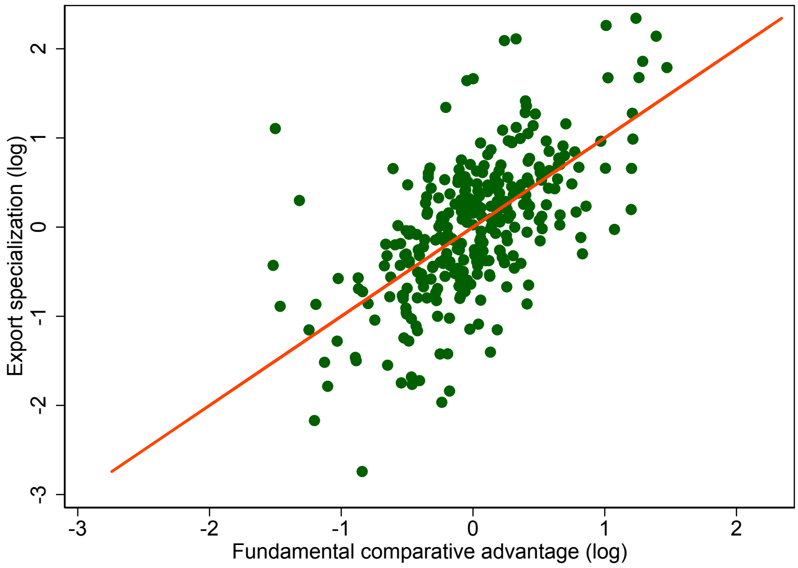
Source: Authors' calculations using the OECD-Eurostat Trade by Enterprise Characteristics database. Note: XS=Export specialization. Among industries with export specialization >1, granular industries are defined as those where granular comparative advantage is larger than fundamental comparative advantage.

Table 5: 2008 vs 2013. Granular industries by country

	2008			2013		
Country	% of granular industries	Share of granular in XS >1 industries	% of granular exports	% of granular industries	Share of granular in XS >1 industries	% of granular exports
Average country	29	58	43	26	53	41
Austria	29	67	38	33	64	36
France	14	30	14	10	18	13
Germany	29	60	53	19	40	36
Hungary	43	100	78	29	86	65
Italy	38	62	27	19	40	19
Lithuania	33	70	59	29	60	62
Poland	29	67	61	38	73	64
Portugal	10	29	10	14	33	14
Slovakia	43	69	67	39	70	62
Spain	10	18	4	19	33	13

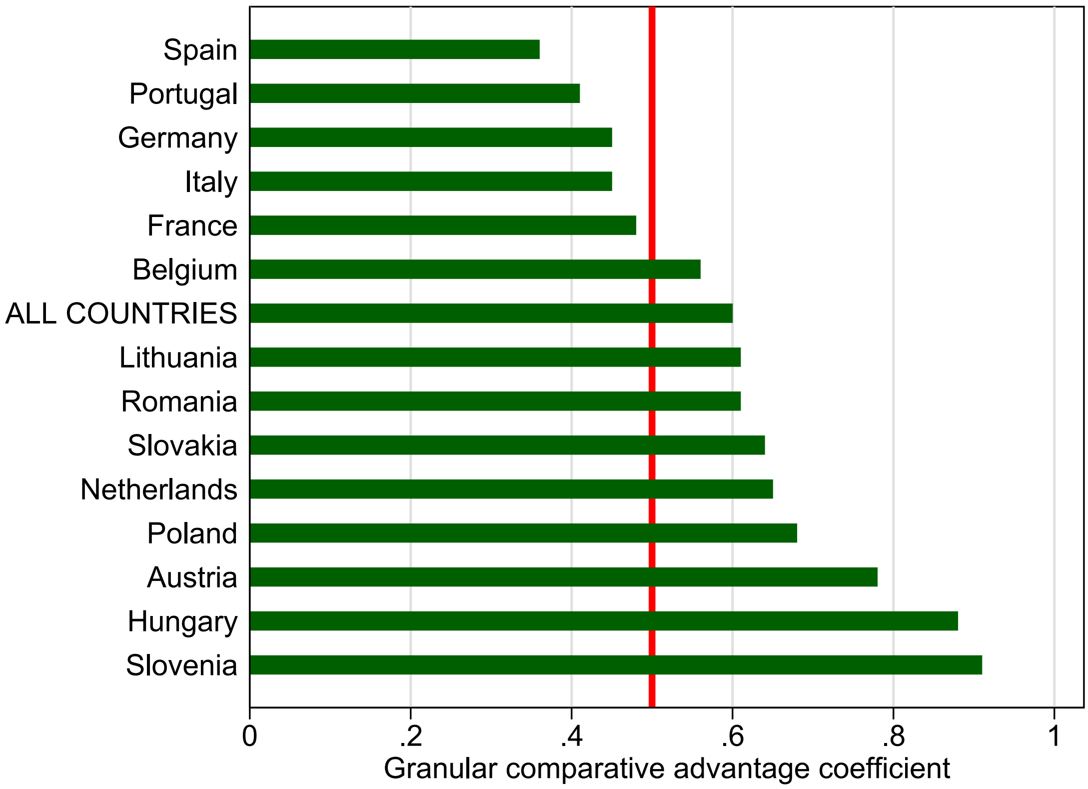
Source: Authors' calculations using the OECD-Eurostat Trade by Enterprise Characteristics database. Note: XS=Export specialization. Among industries with export specialization >1, granular industries are defined as those where granular comparative advantage is larger than fundamental comparative advantage.

Figure 1: (Log) Export specialization vs. (log) fundamental comparative advantage (Average 2008-2013)



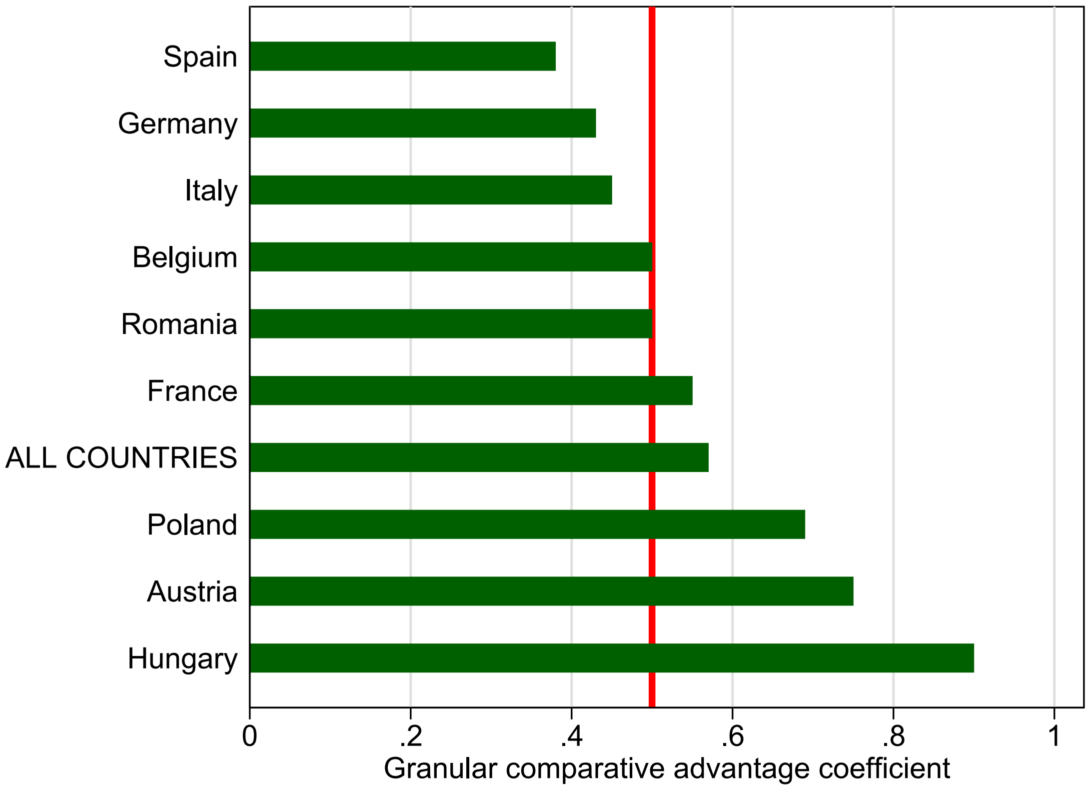
Source: Authors' calculations using the OECD-Eurostat Trade by Enterprise Characteristics database.

Figure 2: Contribution of granular comparative advantage to variation in export specialization. Regression-based decomposition (Average 2008-2013)



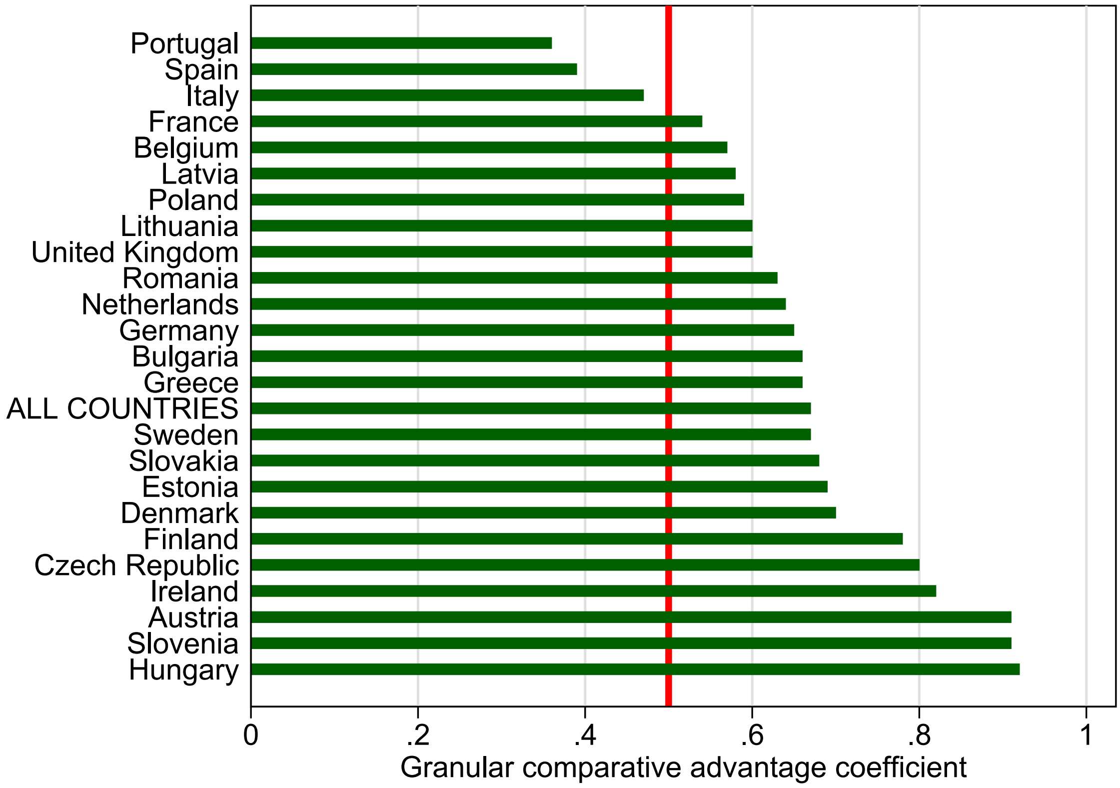
Source: Authors' estimations using the OECD-Eurostat Trade by Enterprise Characteristics database. Note: To calculate the contribution of granular comparative advantage we regress granular comparative advantage on export specialization. ALL COUNTRIES' regression pools the observations from all countries and industries. The figure reports the β_2 coefficients of equation (13).

Figure 3: Small firms removed. Contribution of granular comparative advantage to variation in export specialization. Regression-based decomposition (Average 2008-2013)



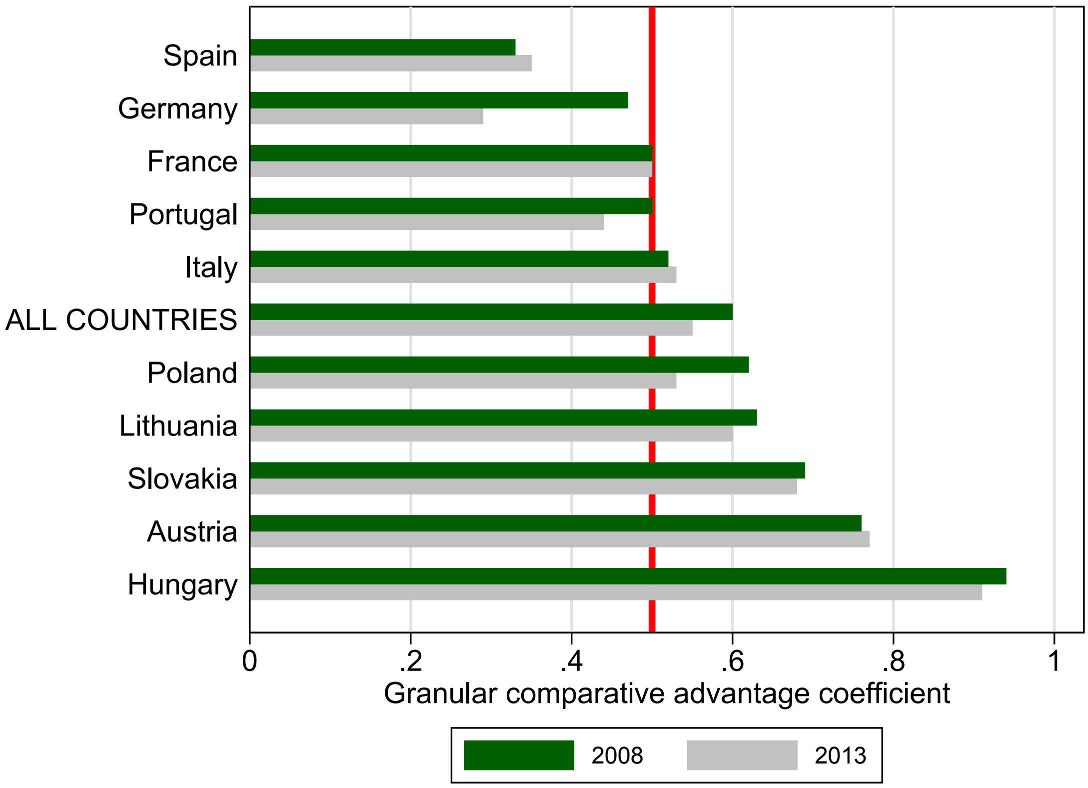
Source: Authors' estimations using the OECD-Eurostat Trade by Enterprise Characteristics database. Note: To calculate the contribution of granular comparative advantage we regress granular comparative advantage on export specialization. ALL COUNTRIES' regression pools the observations from all countries and industries. The figure reports the β_2 coefficients of equation (13).

Figure 4: Extended sample. Contribution of granular comparative advantage to variation in export specialization. Regression-based decomposition (Average 2008-2013)



Source: Authors' estimations using the OECD-Eurostat Trade by Enterprise Characteristics database. Note: To calculate the contribution of granular comparative advantage we regress granular comparative advantage on export specialization. ALL COUNTRIES' regression pools the observations from all countries and industries. The figure reports the β_2 coefficients of equation (13).

Figure 5: 2008 vs 2013. Contribution of granular comparative advantage to variation in export specialization. Regression-based decomposition



Source: Authors' estimations using the OECD-Eurostat Trade by Enterprise Characteristics database. Note: To calculate the contribution of granular comparative advantage we regress granular comparative advantage on export specialization. ALL COUNTRIES' regression pools the observations from all countries and industries. The figure reports the β_2 coefficients of equation (13).

Appendix A The intensive and the extensive margin of exports in Chaney (2008)

In this Appendix, we derive the intensive and extensive margin of exports from Chaney (2008). In this model, firms produce horizontally-differentiated varieties within an industry. Labor is the only production factor. For industry k, the preferences of a representative consumer are given by a constant elasticity of substitution (CES) utility function:

$$U = \left(\int_{v \varepsilon \Omega_k} q^{\frac{\sigma-1}{\sigma}} dv \right)^{\frac{\sigma}{\sigma-1}}, \sigma > 1 \tag{A1}$$

where v is a variety that belongs to the set of varieties of industry k (Ω_k), q is the quantity consumed of variety v, and σ is the elasticity of substitution across varieties. It is assumed that σ is common across industries.

In a CES utility framework, the demand of country j of an industry k variety produced in country i is determined by the following expression:

$$q_{ijk} = \beta_{jk} Y_j (P_{jk})^{\sigma-1} (p_{ijk})^{-\sigma} \tag{A2}$$

where β_{jk} is the share of income (Y_j) that country j devotes to industry k, and P_{jk} is the price index of industry k varieties in country j.

Since there is monopolistic competition, firms set prices as a constant mark-up over marginal costs

$$p_{ijk} = \frac{\sigma}{\sigma - 1} c_{ijk} \tag{A3}$$

where c_{ijk} is the marginal cost of selling a unit of an industry k variety in country j. This cost is determined by the following expression:

$$c_{ijk} = \frac{\tau_{ijk} w_i}{z} \tag{A4}$$

where τ_{ijk} is an iceberg-type trade cost, denoting the units of an industry k variety that should be sent from country i to country j to ensure that one unit arrives; w_i is the wage in country i, and z is the productivity of the firm.

Combining (A2), (A3) and (A4), exports per firm are given by

$$x_{ijk} = \beta_{jk} Y_j (P_{jk})^{\sigma-1} \left(\frac{\sigma}{\sigma - 1} \frac{\tau_{ijk} w_i}{z} \right)^{-\sigma} \tag{A5}$$

Firms will export to country j if they obtain profits. This happens when the following condition is met

$$(p_{ijk} - c_{ijk}) q_{ijk} > F_{ijk} \tag{A6}$$

where F_{ijk} is the fixed costs that a firm in i has to cover if it wants to export a k industry variety to country j. Substituting (A2), (A3) and (A4) in (A6) we get

$$z > \left(\frac{F_{ijk}}{\mu \beta_j Y_j} \right)^{(1/\sigma - 1)} \left(\frac{w_i \tau_{ijk}}{P_{jk}} \right) \tag{A7}$$

where $\mu = (\sigma - 1)^{\sigma-1} \sigma^{-\sigma}$.

If we substitute the inequality in (A7) with an equality, we get the threshold productivity that firms in country i should reach to export a variety of industry k to country j

$$z_{ijk} = \Big(\frac{F_{ijk}}{\mu\beta_{jk}Y_j}\Big)^{(1/\sigma-1)}\Big(\frac{w_i\tau_{ijk}}{P_{jk}}\Big) \tag{A8}$$

There is a large exogenous pool of firms, M_{ik}, that can potentially enter industry k in country i. The value of industry k exports from country i to country j will be determined by the sum of exports of the potential entrants that reach a productivity equal or above the threshold productivity to export. Since productivity is Pareto distributed, the probability density function is given by

$$G(z) = \frac{\theta\varphi_{ik}^{\theta}}{z^{\theta+1}} \tag{A9}$$

where φ_{ik} is the minimum productivity that firms in country i can get in industry k, and θ measures the heterogeneity in the distribution of productivity.[18]

The amount of k industry exports from region i to country j is determined by

$$X_{ijk} = M_{ik}\int_{z_{ijk}}^{-\infty}\beta_{jk}Y_j(P_{jk})^{\sigma-1}\Big(\frac{\sigma}{\sigma-1}\frac{\tau_{ijk}w_i}{z}\Big)^{-\sigma}\frac{\theta(\varphi_{ik})^{\theta}}{z^{\theta+1}}dz \tag{A10}$$

Solving the integral in (A10), we get

$$X_{ijk} = T_{ik}\beta_{jk}Y_j\frac{\theta}{\theta-\sigma-1}z_{ijk}^{\sigma-\theta-1}\Big(\frac{\sigma}{\sigma-1}\frac{P_{jk}}{\tau_{ijk}w_i}\Big)^{\sigma-1} \tag{A11}$$

where

$$T_{ik} = M_{ik}(\varphi_{ik})^{\theta} \tag{A12}$$

denotes the overall productivity of country i in industry k.

The number of firms in country i that export an industry k variety to country j is given by

$$N_{ijk} = M_{ik}\int_{z_{ijk}}^{-\infty}\frac{\theta(\varphi_{ik})^{\theta}}{z^{\theta+1}}dz = T_{ik}z_{ijk}^{-\theta} \tag{A13}$$

To get the average exports per firm, also denoted as the intensive margin of exports, we divide (A11) by (A13)

[18] For stability, it is also assumed that $\theta > \sigma - 1$.

$$\overline{x}_{ijk} = \frac{X_{ijk}}{N_{ijk}} = \beta_{jk} Y_j \frac{\theta}{\theta - \sigma - 1} \underline{z}_{ijk}^{\sigma-1} \left(\frac{\sigma}{\sigma - 1} \frac{P_{jk}}{\tau_{ijk} w_i} \right)^{\sigma-1} \quad \text{(A14)}$$

If we substitute (A8) in (A14), the variables β_{jk}, Y_j, P_{jk}, τ_{ijk} and w_i cancel out, leaving the expression

$$\overline{x}_{ijk} = \left(\frac{\theta\sigma}{\theta - \sigma + 1} \right) F_{ijk} \quad \text{(A15)}$$

Appendix B Numerical simulations on the coefficient of variation of the ratio of exporters ratios

We use numerical simulations to analyze whether the realized ratio of exporters ratios differs significantly from the ratio of exporters ratios we would observe if the number of entrants was large.

Eaton et al. (2012) show that if the number of entrants is small the number of exporters in country i industry k follows a Poisson distribution with parameter $\lambda = M_{ik}(\underline{z}_{ijk}/\varphi_{ik})^{-\theta}$. To get a realized number of exporters, we combine alternative values for M_{ik}, $\underline{z}_{ijk}/\varphi_{ik}$ and θ. For the number of draws, following Gaubert and Itskhoki (2018) we select 700 as the minimum value of draws and 5000 as the maximum value. The $\underline{z}_{ijk}/\varphi_{ik}$ measures the minimum productivity that firms in country i need to reach in order to export industry k varieties to country j, relative to the fundamental productivity of firms in country i and industry k. We approximate this ratio with the exporters' labor productivity premium estimated by the empirical literature. Bernard et al. (2007a) report that value-added per worker is 11% larger in exporters than non-exporters in the US, once industry effects are controlled for. We select this as the minimum value and set the maximum at 50%. Following Eaton et al. (2012) and Gaubert and Itskhoki (2018) we consider $\theta = 5$. As a lower bound, from Crozet and Koenig (2010), we take $\theta = 3$.[19]

For each N in the ratio of exporters ratios in (10), we draw a random number from its Poisson distribution, and calculate the realized ratio of exporters ratios. We repeat this process 100 times. Then, we calculate the coefficient of variation of the realized ratio of exporters ratios relative to the ratio we would observe if the number of draws was large. Table A1 presents the results of the simulations.

In Simulation 1, we set $M_{ik} = 5000$, $\underline{z}_{ijk}/\varphi_{ik} = 1.11$, and $\theta = 5$ for all countries and industries. Simulation 1 yields a coefficient of variation equal to 0.037. Since distributions with a coefficient of variation less than one are considered to be low-variance, we can qualify this value as very low. Simulation 2 lowers the number of draws to 700. Even

[19] Table 3 in Crozet and Koenig (2010), trade-weighted mean.

Table A1: Numerical simulations of the ratio of exporters ratios' coefficient of variation

Simulation	M_{ik}	$M_{ik'}$	$M_{i'k}$	$M_{i'k'}$	θ	$\underline{z}_{ijk}/\varphi_{ik}$	$\underline{z}_{ijk'}/\varphi_{ik'}$	$\underline{z}_{i'jk}/\varphi_{i'k}$	$\underline{z}_{i'jk'}/\varphi_{i'k'}$	Coefficient of variation
1	5,000	5,000	5,000	5,000	5	1.11	1.11	1.11	1.11	0.037
2	700	700	1000	1000	5	1.11	1.11	1.11	1.11	0.105
3	700	700	700	700	5	1.50	1.50	1.50	1.50	0.183
4	700	700	700	700	3	1.11	1.11	1.11	1.11	0.091

with a smaller number of draws, the variation coefficient is 0.087 only. Simulation 3 raises $\underline{z}_{ijk}/\varphi_{ik}$ to 1.5. The variation coefficient rises to 0.183, but is still much below the benchmark value of 1. Finally, Simulation 4 lowers the θ parameter to 3. The variation coefficient drop to 0.091.